CONFERENCE REPORT

on

COTTON INSECT RESEARCH AND CONTROL, MEMPHIS, TENNESSEE, December 4-6, 1950

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This is a summary report of the Conference of State and Federal workers concerned with cotton insect research and control, held at Memphis, Tennessee, December 4-6, 1950. It brings together the results of recent research and experience in the control of cotton insects.

The results summarized in this report will aid in the preparation of recommendations that may be issued by State agencies and the U. S. Department of Agriculture on cotton insect control for 1951. The report is being distributed to entomologists, research and extension workers, the insecticide industry, and others interested in cotton production. Copies are not available for general distribution.

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This report supersedes the Conference Report on Cotton Insect Research and Control, Jackson, Mississippi, November 28-30, 1949.

Contents

COTTON INSECT RESEARCH AND CONTROL

Introduction

Research and extension entomologists and associated technical workers from 12 cotton-growing States (Alabama, Arkansas, Georgia, Illinois, Louisiana, Mississippi, Missouri, North Carolina, Oklahoma, South Carolina, Tennessee, and Texas), Puerto Rico, the United States Department of Agriculture, and the National Cotton Council of America participated in a conference at the Gayoso Hotel, Memphis, Tennessee, December 4-6, 1950, to review and summarize their experiments and experiences in cotton insect control and to formulate a guiding statement for control recommendations in 1951. After a review of all available information, the report that follows was agreed upon by all the conferees.

Cultural methods as well as the use of insecticides for controlling cotton pests are considered in this report. The use of cultural control methods cannot be too strongly emphasized. It should be recognized that control of cotton insects by the use of insecticides is really supplemental to the adoption of good farm practices. These include such factors as early fall clean-up before frost, seed treatment, early planting, fertilization, use of proper cotton varieties, proper land use, and cultivation. Cultural measures are influenced by climate, soil conditions, fertility, topography, and geographical location.

In addition to recommendations for the use of certain insecticides for the control of cotton insects, the report presents information believed to be of value to industry in planning production programs and to aid State and Federal workers who cooperate with cotton growers in testing some of the insecticides that are still in an experimental stage. It contains some suggestions as to research needs in developing a more effective cotton insect control program. A general statement of plans by which the extension entomologists will aid in bringing the 1951 cotton insect control recommendations for each State to the attention of growers and all other interested groups is included. Control recommendations are presented in a general manner and are not specifically fitted to local needs. It is expected that each State, in preparing recommendations for cotton insect control for 1951, will adapt to its own conditions the information given in this summary.

Policy and Ethics

The chief purpose of the Cotton Insect Conference is to enable State and Federal entomologists to make readily available to each other information which may be useful in further research and extension work in cotton insect control. This exchange of information makes possible mutual support. The obvious purpose of improvement of research and extension work in cotton insect control is to reduce losses caused by insects.

While agreement on major recommendations may be expected, complete standardization is not possible. The details of recommendations must vary with the requirements of the region or locality. Such differences are sometimes interpreted as disagreement among entomologists and can be a basis for confusion. To avoid this confusion cotton growers should follow the advice of qualified entomologists in their respective States who are familiar with their local problems.

It should be recognized that procedures, equipment, and materials are now known that may be effectively used in control of the various insect pests of cotton. This adds to the stability of control recommendations. Research is continued, however, to find new procedures, equipment, or materials which may have advantages over those now in use. In bringing the results of new research to public attention, the impression that a panacea for all problems is being introduced tends to discredit all other work and should be forestalled. It is desirable that the results of research should not be reported to the public or made a basis for recommendations until they have been made available to other entomologists working in the same field.

In making recommendations for the use of insecticides, entomologists should recognize their responsibility with regard to the hazards to public safety and other interests involved in the use of such materials.

Unfortunately, through the years there have been put on the market various so-called boll weevil "remedies" that were of little or no value, and even where they had some slight value, they were usually less effective and more expensive than the standard insecticide formulations that had been widely tested by State and Federal agencies. Cotton growers are urged not to risk wasting money experimenting with new and untried materials or mixtures that have not yet been tested by the State or Federal entomologists. Cotton farmers have been persuaded by salesmen to spend much money in purchasing mixtures and machines that have little or no value in increasing the yields or improving the quality of cotton.

Hazards and Precautions in the Use of Insecticides

The development of the newer synthetic organic insecticides has provided more effective means of controlling insects, but it has also intensified numerous problems, such as hazard to man, domestic animals, crops, and beneficial wild life. With few exceptions, all insecticides are poisonous to animals and man and because of this they should be used with appropriate precautions.

The factor of immediate toxicity of insecticides to the user, to livestock, to beneficial insects, and to plants is of great importance. In addition, there is the effect of chronic toxicity due to repeated exposures, of accumulations in soils, and of residues on treated plants and on adjacent crops caused by drift. Everyone concerned with insecticides and

their use should be thoroughly familiar with these various hazards and should take proper precautions when formulating, packaging, labeling, and applying the materials.

Precautions for the User

In considering the hazards to man, it is necessary to distinguish between the immediate hazards (acute toxicity) and the accumulative effects (chronic toxicity). Man can be poisoned by breathing most insecticides or absorbing them through the skin, as well as by swallowing them.

Most solvents used in preparing solutions or emulsions are poisonous, and some are inflammable. Research and experience to date indicate that new chlorinated organic insecticides are reasonably safe to man and the higher animals at strengths normally applied for cotton insect control. In concentrated form, some of the chlorinated hydrocarbon insecticides may cause acute poisoning if they contact the skin or if they are swallowed accidentally. Also, continued contact with or exposure to such materials may result in an injurious accumulation of the toxic ingredient in the body. Persons engaged in applying these insecticides should therefore avoid unnecessary exposure to them. Wearing a respirator with suitable filter pads is advisable. The hands should be washed thoroughly before food is handled. After a dusting or spraying operation is complete, and at least once a day when handling or applying insecticides, it is advisable to bathe and change clothes.

The phosphorus compounds, such as parathion and tetraethyl pyrophosphate, are extremely poisonous materials and must be handled with great care.

It is not practicable to set forth here all precautionary measures that should be taken if phosphorus compounds are used. Such information is available through the Bureau of Entomology and Plant Quarantine and basic manufacturers, and all users should be thoroughly familar with precautions and see that they are followed.

One of the more important precautions to observe is the avoidance of breathing wettable powders, dusts, sprays, or vapors. When handling or applying parathion, use a respirator that has been passed by the U. S. Department of Agriculture.

Loading and mixing should always be done in the open. Impervious gloves should be worn if it becomes necessary to handle the materials, but it is best to avoid any unnecessary contact with insecticide sprays as well as dusts. The concentrated emulsions and wettable powders are especially dangerous. As soon as possible after the use of phosphorus compounds, exposed personnel should bathe and change clothes.

It is advisable to have at hand in the field a change of clothing, soap and water, and a small supply of 1/100-gr. atropine tablets for emergency use, as recommended by competent medical authorities. Quick action is essential in case any symptons of poisoning appear. Persons directing control operations should assume full responsibility for enforcement of adequate precautions and should have had medical advice as to emergency atropine use.

Both spraying and dusting operations should be done under such conditions and in such a manner as to avoid excessive drift to adjacent fields where animals are pastured or where food crops are grown. No organic phosphate should be applied by aircraft or custom sprayer in such a manner that unprotected persons will be exposed to dust or spray. Care in preventing drift is also essential because certain varieties of plants and kinds of crops are injured by certain insecticides. Spillage of insecticides where they might contaminate water used by man or livestock should be avoided. Any excess dusts or sprays, even in small quantities, should be deeply buried.

All empty containers in which insecticides have been packaged should be burned or otherwise destroyed immediately after emptying. Insecticides should always be clearly identified by labels and stored in a place where they are inaccessible to irresponsible persons and to domestic animals.

Equipment used for applying weed killers should not be used for applying insecticides because of danger of crop injury.

Residues in Soils

The effect of insecticides on germination, rate of growth, and flavor of crops may be influenced by type of insecticide, formulation used, soil type, kind of plant, and concentrations of residue in the soil. Information to date indicates that in the amounts and concentrations recommended for the control of cotton insects, no immediate hazard to crop is involved. Injury to several crops by higher rates of application of some insecticides on certain soil types has been demonstrated. Benzene hexachloride may cause off-flavor of peanuts and root crops. The possibility that off-flavor may occur in peanuts grown in fields where cotton was previously treated with benzene hexachloride is being investigated.

Safeguarding Beneficial Forms of Life

Insecticides destroy beneficial as well as injurious insects. Certain materials are also highly toxic to fish and other forms of aquatic life. It is especially important to use minimum amounts where there would be an unavoidable drift to ponds and streams. In disposing of excess

spray or dust materials, or when cleaning dusting or spraying equipment, every precaution should be taken to avoid the pollution of streams and farm ponds stocked with fish.

Preventing Bee Losses

Dusting cotton may cause heavy bee losses. Calcium arsenate appears to be the most dangerous insecticide in this respect because field bees may carry it to the hive where it is fed to the developing brood. The organic insecticides employed for cotton insect control do not reach the brood as does calcium arsenate. Toxaphene appears to be less hazardous to use where bees are working flowers than benzene hexachloride or DDT. Chlordane appears to be more toxic than DDT or benzene hexachloride to bees. No information has been obtained about the effect of aldrin and dieldrin on bees.

To hold bee losses to a minimum, the following suggestions are made:

1. Unnecessary dusting or spraying should be avoided by careful scouting and timing.
2. Cotton growers should notify beekeepers before dusting or spraying so that bees can be moved. Beekeepers should contact cotton growers before the cotton insect control season begins and request their cooperation. County agents may serve as clearing houses for such notifications. County agents and cotton growers should be given the exact location of apiaries.
3. Beekeepers should be kept informed of cotton insect infestations and recommendations for their control. This will enable them to locate bee yards in the safest available places and to know where and when insecticide applications are to be made.
4. Dusting or spraying should be done under good atmospheric conditions and care exercised to avoid drift, particularly into bee yards.
5. Other things being equal, the insecticide should be used that will be the least toxic to bees.
6. Cultural control measures should be used to reduce the necessity of insecticidal control.

If better understanding and cooperation can be developed between beekeepers and cotton farmers, bee losses can be reduced.

Methods of Applying Insecticides

Dusts

The new organic insecticides are used as toxicants in dust mixtures with carriers such as talcs, pyrophyllite, and clays, or in mixtures with other insecticides. Too much emphasis cannot be placed upon proper formulations.

Progress has been made in the formulation of good quality dusts for use on cotton. However, in some instances research workers have attributed erratic results and poor control to inferior dusting qualities of the mixtures. The use of mixtures with excellent dusting qualities is in the interest of insecticide conservation, essential in view of the present insecticide supply situation. More information is needed concerning insecticidal formulations to establish criteria for suitable organic dust mixtures.

Sulfur as a diluent gives dust mixtures certain undesirable physical properties. The supply of sulfur is short for 1951 and it should not be used as a diluent for other insecticides. However, in those areas where spider mites are usually a problem, 40 percent of a good grade of dusting sulfur or some other suitable miticide is desirable in the mixture.

Sprays

Several organic insecticides applied in spray form were used widely during 1950. Results during the last three years have shown that concentrated sprays of organic insecticides applied with ground equipment and airplanes gave control of cotton insects equal to that obtained with dusts. Sprays have a wide range of usage in that they can be applied during most of the daylight hours, even under conditions of relatively strong winds (15 miles per hour). Boll weevil control has been obtained with as little as 1 gallon or as much as 15 gallons of spray per acre with the toxicant remaining constant at the recommended rate. Sprays have been successfully applied to cotton for control of boll weevils, bollworms, pink bollworms, thrips, cutworms, cotton fleahoppers, tarnished plant bugs, rapid plant bugs, cotton aphids, various pentatomids, garden webworms, and spider mites. Most of the new organic insecticides can be made into emulsifiable concentrates, which with the addition of water give emulsions suitable for application. Slight foliage burning has been noted in some instances when the emulsifiable concentrate was poorly formulated, or when the emulsion was improperly applied, or poorly distributed.

Most oil solutions of insecticides which have been tested caused foliage injury. Tests of experimental oils indicate that the viscosity and volatility of the oil and its aromatic content are the main factors causing the undesirable foliage reaction.

Solvents with a relatively low boiling range and aromatic content which will dissolve the toxicant appear to be the most desirable for use in emulsifiable concentrates. Emulsifiers and solvents should be tested for toxicity to the cotton plant and their general suitability determined before they are used in formulations.

In general, the mass median diameter of the spray droplets should range from 100 to 300 microns. Manufacturers' recommendations should be followed in regard to pressure for specific nozzle size to insure a proper spray pattern.

For treatment of seedling cotton in most areas it is suggested that with ground equipment one nozzle per row be used to apply the spray and, as the cotton increases in size, the number of nozzles per row be increased up to three to obtain full coverage. If nozzles are kept at least 10 inches from the plant, the danger of leaf burn is minimized.

For use in ground equipment, it is essential that spray concentrates be diluted immediately prior to use with not to exceed an equal volume of water, and the diluted emulsion then added to the required volume of water. During the spray operation some type of agitation is essential in order to insure a uniform emulsion.

As a safety measure, it is recommended that the spray boom on ground equipment be located behind the operator.

For airplane spray application, it is suggested that from 1 to 2 gallons of spray containing the recommended rate of toxicant be applied per acre. It is essential to use some method of flagging or marking of swaths for best results in airplane spraying.

For stability in storage and to prevent breakdown of the formulation when metal containers are used, the containers should be lined with some material that will not react with or cause deterioration of the concentrate. It is desirable that the insecticides be prepared in such a way that they may be combined with each other to form a satisfactory emulsion.

It is suggested that whenever possible the manufacturers prepare formulations in even multiples of the amounts of insecticide recommended per acre. The pounds per gallon of each insecticide in the concentrate should be shown on the label.

Insecticides

The experimental data and the results of field tests presented at the Conference showed that no particular insecticide gave results outstandingly superior to those of any other recommended insecticide or mixtures of materials when they were used according to the recommendations of the official entomologists and at the dosage, time, and frequency recommended. The most important factors in the effective use of insecticides for cotton insect control are the dosage, timing, frequency, and thoroughness of application.

Aldrin

Aldrin received wide usage for cotton insect control during 1950. In most cases, it will control the boll weevil, thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, grasshoppers, and newly hatched cotton leafworms. It will not control the bollworm, the cotton aphid, or spider mites. For boll weevils, aldrin should be applied at the rate of 0.25 to 0.5 pound per acre. Aldrin is effective as a dust or as a spray.

Aldrin is toxic by skin absorption, by inhalation, and by ingestion. It is recommended for use on cotton only where persons applying it are fully aware of the hazards and will follow the precautions prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Benzene Hexachloride

Benzene hexachloride will control the boll weevil, the cotton aphid, the tarnished plant bug, the rapid plant bug, the cotton leafworm, thrips, the southern green stink bug, the garden webworm, the fall armyworm, the cotton fleahopper, and grasshoppers. It will not control the bollworm, the pink bollworm, the salt-marsh caterpillar, and spider mites. For this reason, benzene hexachloride alone cannot be successfully employed for over-all cotton insect control. Benzene hexachloride also kills many beneficial insects.

In dusts, benzene hexachloride at approximately 0.3 pound of the gamma isomer per acre (example: 10 pounds of benzene hexachloride dust containing 3 percent of the gamma isomer) is the minimum rate which has consistently given satisfactory control of all cotton insects for which it is recommended. The most common commercial dust formulations containing benzene hexachloride used by cotton growers contain 3 percent of the gamma isomer and 5 percent of DDT, with or without sulfur.

A spray formulation containing sufficient technical benzene hexachloride to give 0.3 or 0.4 pound of the gamma isomer plus 0.5 pound of technical DDT per acre has given satisfactory control of the boll weevil and the bollworm. Proper formulation of the emulsion concentrate is necessary to prevent foliage or plant injury.

Benzene hexachloride is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions should therefore be observed in its use.

Grain sorghum, barley, cowpeas, and some other crops are adversely affected by benzene hexachloride. Further research is needed concerning the accumulation of this insecticide in the soil following applications to cotton and the resultant effects on other crops. Until more is known

regarding the danger of possible off-flavor in peanuts, Irish potatoes, and some other crops, it is inadvisable to use benzene hexachloride for cotton insect control where the land will later be planted to these crops.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Calcium Arsenate

Calcium arsenate is an economical and effective insecticide for control of the boll weevil and the cotton leafworm, and has excellent dusting qualities. It is used at the rate of 7 to 10 pounds per acre for boll weevil and cotton leafworm control. Twelve to 15 pounds per acre will control bollworms if applications are properly timed and infestations are not too heavy. It is usually used undiluted against the above-mentioned insects. When used without an aphidicide an increase in aphid population often results (see Nicotine, p. 15).

Lime-free calcium arsenate is compatible with organic insecticides. When this calcium arsenate is used with parathion (see precautions under Parathion, p. 16), the boll weevil, the cotton aphid, and spider mites may be effectively controlled. When lime-free calcium arsenate is combined with 5 percent of DDT and 1 percent of parathion, effective control of the boll weevil, the bollworm, the cotton aphid, and spider mites are obtained. Lime-free calcium arsenate in combination with these materials should be applied at the rate of 10 to 12 pounds per acre.

Calcium arsenate in certain light sandy soils is injurious to some crops, especially legumes and oats. It should not be used for cotton insect control in fields where rice may be planted. Drifting of the dust may injure other crops. Precautions should be taken to avoid drift that might cause bee losses. Calcium arsenate is poisonous and should be handled carefully. Livestock should be kept out of dusted fields. Care should be taken to avoid drift onto pastures, especially when applications are made by airplane.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Chlordane

Chlordane will control the boll weevil, the cotton fleahopper, the tarnished plant bug, grasshoppers, sand wireworms, and thrips. It will not control the bollworm, the cotton aphid, the pink bollworm, and spider mites. Although it kills a high percentage of boll weevils in squares and bolls, the practical benefit derived therefrom has not been demonstrated.

For the insects against which chlordane is effective, from 0.5 to 1.5 pounds of technical material per acre is required.

For over-all cotton insect control, chlordane should always be formulated with DDT and the rate of application should be such that from

1 to 1.5 pounds of technical chlordane and from 0.5 to 0.75 pound of technical DDT per acre will be applied.

The dust formulation generally recommended should contain 10 percent of chlordane plus 5 percent of DDT and should be applied at the rate of 10 to 15 pounds per acre. Sprays should contain 2 parts of chlordane to 1 part of DDT.

These formulations have given excellent results in some areas, while in others the results have been erratic.

The cotton aphid and spider mites may increase to damaging proportions after applications of chlordane-DDT sprays and dusts. Careful inspections for these two pests should be made at weekly intervals after the application of chlordane-DDT formulations; and, if an increase of either species is observed, appropriate measures, as outlined under the respective pests, should be taken to control them.

The toxicity of chlordane to higher animals is greater than that of DDT. Operators should avoid breathing the dust or mist. Contamination of food and feed crops around cotton fields should be avoided.

Little is known regarding possible ill effects on plants from accumulations of chlordane in soils.

See Hazards and Precautions in the Use of Insecticides, p. 4.

DDT

DDT will effectively control the bollworm, the pink bollworm, the fall armyworm, the tarnished plant bug, some species of stink bugs, the rapid plant bug, the cotton fleahopper, and thrips. Unsatisfactory results were reported in some instances when the temperature exceeded 90° F. To a lesser extent it will also control certain species of cutworms. It will not control the boll weevil, the cotton leafworm, spider mites, the cotton aphid, and grasshoppers.

As a dust on cotton, DDT is ordinarily used at concentrations of 5 to 10 percent. It is used either alone or in combination with other insecticides and miticides, and at rates of 10 to 20 pounds per acre. However, not less than 15 pounds per acre of 10 percent DDT should be used for pink bollworm control.

Sprays and dusts containing DDT are about equal in effectiveness against cotton pests. Thorough coverage of the plant and proper timing of applications are more important than the type of formulation used.

Where DDT is used, aphid and mite populations may increase until severe injury occurs unless an aphidicide and a miticide are included in the treatment.

DDT is toxic to certain plants such as cucurbits. Its toxicity persists and accumulates in the soil, and therefore it should be used only in the minimum amounts recommended for cotton insect control, especially on light sandy soils.

In applying DDT, contamination of adjacent crops from drift should be avoided.

DDT is highly toxic to fish and amphibians, and precautions should be taken to avoid the possibility of stream pollution.

Acute toxicity of DDT to man and animals is rather low as compared with the inorganic insecticides now in use on cotton. However, when DDT is repeatedly ingested or brought into contact with the skin it is absorbed and may be stored in the fatty tissues. Injury to liver may also result. Unnecessary exposure of operators should therefore be guarded against.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Dieldrin

Dieldrin was used experimentally for cotton insect control in many locations throughout the Cotton Belt in 1950. It was effective against the boll weevil when applied at the rate of 0.15 to 0.4 pound per acre. It was effective against thrips, the cotton fleahopper, the tarnished plant bug, the rapid plant bug, the fall armyworm, grasshoppers, and the variegated cutworm when applied at dosages of 0.05 to 0.15 pound per acre. It was not effective at low dosages for bollworm control, and DDT should be added when control of this insect is necessary. Dieldrin will kill newly hatched cotton leafworms at dosages effective against the boll weevil.

Large-scale field experiments, small-scale field tests, and field and laboratory cage tests all indicate that dieldrin is a highly effective insecticide for controlling many of the injurious cotton insects. It is effective either as a dust or a spray.

In some States entomologists may not make general recommendations for the use of dieldrin because of absence of sufficient information relative to the hazards associated with its use under the conditions in their State.

Although not extremely poisonous acutely, dieldrin may accumulate in animal tissues and its toxic effects may be delayed for several days or even weeks. It is reported by some investigators to be more poisonous by skin absorption than by ingestion. Its chronic effects are not fully determined.

Dieldrin is suggested for use in the control of cotton insects only where persons associated with its application and use are aware of the hazards involved and are supervised by individuals who are in a position to assume full responsibility and enforce the observance of precautionary measures prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Heptachlor

Laboratory and field tests indicate that heptachlor deserves further field evaluation to determine its possible usefulness in the control of cotton insects. In field tests conducted in Texas, Mississippi, and South Carolina during 1950, heptachlor was effective in controlling the boll weevil when applied at the rate of 0.5 to 0.75 pound of the technical material per acre in either dust or spray form. It did not control the bollworm and therefore should be mixed with DDT at the recommended rates whenever it is used for mid-season or late-season boll weevil control. It is not recommended for general boll weevil control, but the 1950 data suggest that it be widely tested in large-scale experiments. Laboratory tests indicate that heptachlor is effective against the variegated cutworm, thrips, and the salt-marsh caterpillar.

Heptachlor did not control the bollworm, the cotton leafworm, the cotton aphid, or spider mites.

Heptachlor is more toxic to higher animals than chlordane. Operators should avoid breathing dusts and avoid unnecessary contact with sprays containing this material. Little is known regarding the effect of repeated or prolonged exposure to heptachlor or the possible ill effects on plants from accumulations of it in soils.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Lindane

Lindane, the essentially pure gamma isomer of benzene hexachloride, may be substituted on an equivalent weight basis for the gamma isomer of benzene hexachloride in formulations of insecticides used on cotton insects.

Lindane is toxic to warm-blooded animals. It may enter the body through absorption, inhalation, or ingestion. Proper precautions should therefore be observed in its use.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Methoxychlor

Dusts containing 10 percent of methoxychlor controlled the cotton leafworm, but lower concentrations gave poor control.

Methoxychlor gave slightly better pink bollworm control than DDT, but a heavy build-up of aphids usually followed its use and it failed to control bollworms. For these reasons it is not being generally used for pink bollworm control.

Methoxychlor is less effective than the insecticides now recommended for the control of the boll weevil, the bollworm, the cotton aphid, the garden webworm, spider mites, and stink bugs.

Toxicological studies show that methoxychlor is less toxic than DDT to warm-blooded animals and that it is less likely to be stored in the fat or excreted in the milk.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Nicotine

Two percent of nicotine in alternate applications of calcium arsenate, if properly applied (the period between nicotine applications not to exceed 8 to 10 days), will usually prevent a cotton aphid build-up.

Either 2 or 3 percent of nicotine in a suitable carrier can be used to knock out heavy aphid infestations. At least 0.2 pound per acre of free-nicotine equivalent should be applied. The source may be either nicotine sulfate or a fixed nicotine in dust form.

Applications of nicotine dust to knock out heavy aphid infestations should be applied when the air is calm and preferably when there is no dew on the plants. Complete coverage is essential.

Nicotine is highly toxic to man and animals and should be used with adequate precautions.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Octamethyl Pyrophosphoramide

This material and related so-called systemic poisons are in preliminary stages of investigation and they are not recommended.

In laboratory tests, octamethyl pyrophosphoramide was translocated by cotton plants when applied to the soils in which the plants were growing. A single soil application of 4 to 8 pounds per acre of the technical compound caused the plants to remain toxic to cotton aphids and spider mites for several months. Lower dosages were ineffective. Spray application to foliage of 1 pound of the compound per acre gave aphid and mite protection for 2 to 4 weeks. Cotton seedlings grown from seed treated with 1 pound of octamethyl pyrophosphoramide per 100 pounds of seed were toxic to aphids and mites for 6 weeks. Higher dosages reduced seed germination. Octamethyl pyrophosphoramide was ineffective against the boll weevil, the bollworm, the cotton leafworm, the cotton fleahopper, thrips, and a number of other cotton insects.

Octamethyl pyrophosphoramide is an extremely dangerous poison to man and other animals. In handling it, the same precautions as indicated for parathion should be followed. Until investigations disclose that this material does not persist, cottonseed meal or other cottonseed products from treated plants should not be fed to livestock.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Parathion

Parathion will control the cotton aphid, spider mites, the garden webworm, and the cotton leafworm. It may be used as a 1-percent dust alone or in combination with other insecticides. It gives very little control of the boll weevil, the bollworm, and the pink bollworm.

Parathion is an extremely dangerous poison. It is not recommended for general use. However, when other suitable insecticides are not available and in other emergency situations, its use on cotton may be justified and recommended where qualified personnel are in a position to assume full responsibility and to enforce proper precautions as prescribed by the manufacturers.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Rotenone

Calcium arsenate plus 1 percent of rotenone at each application made against the boll weevil has given satisfactory control of the cotton aphid. For various reasons there may be more occasion for recommending rotenone for cotton aphid control in 1951 than there has been in recent years.

Sulfur

Sulfur has been widely used on cotton for control of spider mites and the cotton fleahopper. When used in dust mixtures it sometimes has a repressive effect upon aphid populations in some areas. Where spider mites are likely to be a serious problem, 40 percent of sulfur or some other suitable miticide should be included in organic insecticide dusts to prevent the development of damaging mite infestations. The supply of sulfur is short for 1951 and it should not be used as a diluent for other insecticides.

Tetraethyl Pyrophosphate (TEPP)

Tetraethyl pyrophosphate, commonly referred to as TEPP, is highly effective as a spray against the cotton fleahopper, the cotton aphid, and spider mites when used on dry plants. Experiments indicate that applications containing 0.5 pint of 40 percent tetraethyl pyrophosphate, or its equivalent, per acre effectively control heavy populations of these pests.

Tetraethyl pyrophosphate is an extremely dangerous poison. It is recommended for use on cotton only where a qualified person is in a position to assume full responsibility and to enforce proper precautions as prescribed by the manufacturers. It deteriorates very rapidly when

exposed to moisture or moist air and is incompatible with alkaline materials. The residual toxicity of this chemical is very short.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Toxaphene

Toxaphene will control the boll weevil, the bollworm, the fall armyworm, the tarnished plant bug, the rapid plant bug, the cotton leafworm, cutworms, and grasshoppers when applied at the rate of 2 to 3 pounds of the technical material per acre. It will also control the cotton fleahopper and thrips when applied at the rate of 0.75 to 1 pound of the technical material per acre. Experiments show that dusts and sprays are equally effective in most areas when properly applied.

Bollworm control was improved where DDT was incorporated in the toxaphene spray mixture. Toxaphene alone will not give satisfactory control of the pink bollworm.

Where toxaphene was used throughout the season satisfactory suppression of the cotton aphid resulted. It will not, however, control heavy aphid infestations. It will not control spider mites, and its use may result in their increase; therefore, in some areas it is recommended that the dust contain at least 40 percent of sulfur or some suitable miticide.

No economic injury to cotton has been reported from the use of toxaphene. This material can be handled with relative safety to the operator if proper precautions are taken. Toxaphene is toxic to livestock and poultry, and is very toxic to fish.

See Hazards and Precautions in the Use of Insecticides, p. 4.

Cultural Practices Aid in the Control of Cotton Insects

Certain cultural practices reduce cotton losses from insect pests and often reduce and may eliminate the need for insecticides. The use of such practices should be encouraged. This is especially important when insecticides are in short supply. Several of the following practices may be used by any cotton grower. Others are applicable to certain areas and conditions only. Growers should, in addition to following these practices, continue to make careful observations for insects and apply insecticides when needed.

Planting

Reasonably early planting of all cotton within an area during a short period enables the crop to produce maximum growth and fruit before insects multiply and spread from field to field.

Varieties

Prolific varieties of cotton that fruit early and mature quickly may set a crop before the boll weevil and other insects become numerous, especially if other cultural controls are used.

Soil Improvement

More injury from insects, without yield reduction, can be tolerated by rapid-growing cotton in rich soil than by cotton growing in poor soil. For this reason, practices such as fertilization, rotation of crops, and plowing under of green manure tend to offset insect losses.

Other Host Crops of Cotton Pests

Cotton fields should be located as far as is practicable from other host plants of cotton insects. Thrips breed in onions, potatoes, carrots, and some other crops and later move in great numbers into adjacent or interplanted cotton. Garden webworms and variegated cutworms and Lygus bugs may migrate to cotton from alfalfa. The cotton fleahopper migrates from croton and other weeds.

Hibernation Areas

Boll weevils hibernate during the winter in well-drained, protected areas in and near cotton fields. Spider mites hibernate in low-growing perennials in or near fields. Clean cultivation reduces weevil hibernation quarters. Planting of winter cover crops to improve the soil and prevent erosion is recommended. Small patches of weeds near fields, along turnrows and fences, or around stumps and scattered weeds in cultivated fields or pastures can be destroyed at a small cost. Such practices are more effective where the cotton acreages are in sizeable blocks rather than in small patches. The general burning over of woods is not recommended.

Early Stalk Destruction

The destruction or killing of cotton plants by either mechanical or chemical methods, as early as possible before the first killing frost, forces boll weevils into starvation before they go into winter quarters. The result of early stalk destruction, especially over community- or county-wide areas, has greatly reduced the boll weevil problem in the Lower Rio Grande Valley and in other

parts of Texas. This practice is also recognized as important in pink bollworm control in most areas. Plowing under the crop residue as deeply as possible after the stalks are cut will also reduce the survival of the pink bollworm.

Legumes in Relation to Cotton Insect Control

It is recognized that soil-building and soil-conserving leguminous crops are fundamental in a cotton-growing program. It is further recognized that a number of insects that attack legumes later transfer to cotton, thereby increasing the cotton insect problems. This situation may have a tendency to, but definitely should not, discourage the use of legumes. Entomologists should give serious consideration to insect control for the protection of both legumes and cotton.

Bug-Catching Machines

Bug-catching machines are not recommended as a means of controlling cotton insects.

Chemical Defoliation as an Aid to Insect Control

Defoliation of cotton with chemicals has a direct relation to cotton insect control. Defoliation of cotton has been found to cause boll weevils to leave such fields almost immediately. It also reduces the percentage of locks infested by weevils. Where cotton has been defoliated a much smaller number of weevils have been found the next spring. Damage to open cotton by heavy aphid populations and by late cotton leafworm infestations has been prevented by chemical defoliation.

Proper defoliation checks the growth of the cotton plant and accelerates the opening of the bolls. The crop may be harvested earlier, thereby permitting earlier destruction of the stalks, an important aid in boll weevil and pink bollworm control.

For best results defoliants should not be applied until the last bolls expected to make cotton are at least 25 days old. Satisfactory defoliation cannot be expected if excessive soil moisture, high fertility, or insufficient insect control cause plants to be highly vegetative. Second growth also has been found very difficult to remove with chemical defoliants.

Detailed guides for use of different defoliants, and rates and methods of application will be found in the Annual Report of Progress from the Cotton Defoliation Conference, issued by the National Cotton Council of America, Memphis, Tenn. This report contains information concerning the influence of plant activity, stage of maturity, and effects of environment on efficiency of the process. The report gives details relative to the various needs and benefits and explains how loss in yield and quality of products may be caused by improper timing of the applications.

These guides to the use of the defoliation process are based on broad ecological areas, rather than on State boundaries. Where an individual has any doubt concerning proper methods, time of application, or actual need for the process, he should consult local agricultural specialists.

Cotton Insects

Boll Weevil

The boll weevil, Anthonomus grandis Boh., may be effectively controlled with benzene hexachloride, calcium arsenate, toxaphene, aldrin, and dieldrin. Benzene hexachloride should be applied at a rate of not less than 0.3 pound of the gamma isomer per acre, calcium arsenate at 7 to 10 pounds per acre, toxaphene at 2 to 3 pounds of the technical material per acre, aldrin at 0.25 to 0.5 pound of the technical material per acre, and dieldrin at 0.15 to 0.4 pound of the technical material per acre. When these insecticides are used for boll weevil control under field conditions, other insect problems have to be considered. Infestations of the cotton aphid, the bollworm, and spider mites may develop when some of these insecticides are used alone.

The following dusts have been approved for use in areas where recommended:

1. Benzene hexachloride to give 3 percent of the gamma isomer in the finished dust plus 5 percent of DDT (sometimes referred to as "3-5-0").
2. Calcium arsenate applied alternately with calcium arsenate plus 2 percent of nicotine.
3. Calcium arsenate applied alternately with a mixture of benzene hexachloride (3 percent gamma isomer) and 5 percent of DDT.
4. Lime-free calcium arsenate plus 1 percent of parathion.
5. Lime-free calcium arsenate plus 1 percent of parathion and 5 percent of DDT.
6. Toxaphene 20 percent.
7. Aldrin 2.5 percent.
8. Aldrin 2.5 percent plus 5 percent of DDT.
9. Dieldrin 1.5 or 2.5 percent.
10. Dieldrin 1.5 or 2.5 percent plus 5 percent of DDT.
11. Chlordane 10 percent plus 5 percent of DDT. (This mixture is recommended only in areas where it has given good control. It has given erratic results in some areas, perhaps because of high temperatures and humidity.)

In areas where spider mites are a problem, dust formulations of organic insecticides should contain sulfur or some other suitable miticide.

The following treatments with sprays made from emulsion concentrates have given favorable results and are approved where recommended:

1. Toxaphene at the rate of 2 to 3 pounds of the technical material per acre.
2. Toxaphene and DDT in the ratio of 2 to 1 applied at the rate of 2 to 3 pounds of technical toxaphene per acre.
3. A mixture to give 0.3 to 0.5 pound of the gamma isomer of benzene hexachloride and 0.5 pound or more of technical DDT per acre.
4. Aldrin at the rate of 0.25 to 0.5 pound of the technical material per acre.
5. A mixture to give 0.25 to 0.5 pound of technical aldrin and 0.5 pound or more of technical DDT per acre.
6. Dieldrin at the rate of 0.15 to 0.4 pound of technical material per acre.
7. A mixture to give 0.15 to 0.4 pound of technical dieldrin and 0.5 pound or more of technical DDT per acre.

   In areas where it has proved satisfactory and where it is recommended, a mixture of 1 pound of technical chlordane and 0.5 pound or more of technical DDT per acre may be used.

Control measures directed against the boll weevil should be applied when definite need is indicated. Except where early season control measures are practiced, insecticides should be applied at intervals of 4 to 5 days until the infestation is brought under control. Thereafter, the fields should be inspected weekly and applications made when necessary.

Bollworms

At least four species of lepidopterous larvae damage cotton bolls. The most important are the bollworm, Heliothis armigera (Hbn.), and the tobacco budworm, H. virescens (F.).

During the past two years the tobacco budworm has been the predominant species early in the season in many collections of bollworms from cotton, particularly in the eastern part of the Cotton Belt. The yellow-striped armyworm, Prodenia ornithogalli Guen., and fall armyworm, Laphygma frugiperda (A. & S.), are the others that sometimes cause bollworm injury.

It is often a difficult task to control this group of insects and many erratic results have been reported. Factors which contribute to their abundance are sometimes complex and not too well known. The widespread use of certain of the organic insecticides has often resulted in greatly increased bollworm damage, presumably as a result of killing off the natural enemies. Probably, also, changing farm practices due to diversification and mechanization have resulted in conditions more favorable for the normal increase of these insects.

Effective bollworm control depends on the use of properly formulated insecticides and timeliness and thoroughness of application. Frequent field inspections during the main fruiting period of cotton in any given field to determine the presence of eggs and young larvae are prerequisite to satisfactory bollworm control. After the larvae have already entered the squares and bolls it is too late for effective control.

DDT is the most effective insecticide known for the control of bollworms. It should be applied at the rate of 1 to 1.5 pounds of the technical material per acre in the form of a 10 percent dust or as a concentrated spray. DDT may be used in mixtures with other insecticides where other insects as well as bollworms require control. It is compatible with lime-free calcium arsenate but not with regular calcium arsenate. Where 0.5 pound or more of DDT per acre is applied with other insecticides in the regular schedule for boll weevil control, bollworms are usually controlled.

Toxaphene, at the rate of 2 to 3 pounds per acre, is the next most effective insecticide against bollworms. This may be applied as a 20 percent dust or as a spray. The dust appears to be more effective than the spray, and for this reason the spray is often formulated to contain DDT.

Calcium arsenate and cryolite dusts are less effective.

In areas where spider mites are a problem, dust mixtures containing organic insecticides used for the control of bollworms should include 40 percent of sulfur or some other suitable miticide.

Cotton Aphid

Heavy infestations of the cotton aphid, Aphis gossypii Glov., often occur on cotton after the use of certain insecticides. Infestations may also be severe on seedling cotton where no insecticides have been applied.

The following treatments, which are recommended for general use in cotton insect control, will usually prevent an aphid build-up:

1. A mixture containing 3 percent of the gamma isomer of benzene hexachloride and 5 percent of DDT in every application at the rate of 10 to 12 pounds per acre.
2. A mixture containing 3 percent of the gamma isomer of benzene hexachloride and 5 percent of DDT at the rate of 10 to 12 pounds per acre in alternate applications with calcium arsenate.
3. Nicotine 2 percent in regular calcium arsenate at the rate of 10 to 12 pounds per acre alternated with calcium arsenate alone.
4. Parathion 1 percent in lime-free calcium arsenate at the rate of 10 pounds per acre.

5. Toxaphene at the rate of 2 to 3 pounds of the technical material per acre in every application (where toxaphene is not formulated with DDT).

When heavy infestations of the cotton aphid occur and where the need for rapid kill is indicated, the following treatments are effective:

1. Benzene hexachloride applied to give 0.5 pound of the gamma isomer or an equivalent amount of lindane per acre.
2. A 1-percent parathion dust applied at the rate of 12 to 15 pounds per acre.
3. Nicotine 3 percent in hydrated lime applied at the rate of 10 to 15 pounds per acre.

Another insecticide which will give quick control of heavy infestations of the cotton aphid, but which is not generally recommended because of its toxicity and low residual action, is 0.5 pint of 40 percent tetraethyl pyrophosphate, or its equivalent, per acre.

Cotton Fleahopper

The cotton fleahopper, Psallus seriatus (Reut.), can be controlled with the following dusts: DDT 5 percent, toxaphene 10 percent, dieldrin 1.5 percent, aldrin 2.5 percent, benzene hexachloride (gamma isomer 1 percent), and chlordane 2 percent. When spider mites are likely to be a problem, 40 percent or more of sulfur or a suitable miticide should be added to organic insecticide formulations. Less effective control of the cotton fleahopper may be obtained with sulfur alone or with a 1:1 or 2:1 mixture of calcium arsenate and sulfur.

The following materials applied as low-gallonage sprays at the rates indicated per acre will give good control of the cotton fleahopper: 0.5 pound of DDT, 1 pound of toxaphene, 0.5 pound of toxaphene plus 0.25 pound of DDT, 0.1 pound of dieldrin, 0.2 pound of aldrin or 0.5 pint of 40 percent tetraethyl pyrophosphate.

In some instances cotton aphids develop after the use of DDT dust or spray.

Cotton Leafworm

The cotton leafworm, Alabama argillacea (Hbn.), has been controlled successfully for many years by calcium arsenate, paris green, or lead arsenate. Dust and spray formulations of benzene hexachloride, toxaphene, a mixture of benzene hexachloride and DDT, or a mixture of toxaphene and DDT are effective in controlling the cotton leafworm.

Cutworms

Cutworm outbreaks may develop in weeds or crops, especially legumes. Cutworms migrate to adjacent cotton or attack cotton planted on land previously in weeds or legumes.

Recommended control measures are thorough seed-bed preparation and use of insecticides. Allow at least three weeks to elapse between the time of plowing under an infested area and the subsequent seeding of the cotton crop. Toxaphene or dieldrin sprays and dusts as recommended for boll weevil control are effective. Poison baits containing paris green, sodium fluosilicate, or toxaphene have been found satisfactory. A poison bait consisting of 40 percent of cryolite and 60 percent of citrus meal gives effective control.

Fall Armyworm

The fall armyworm, Laphygma frugiperda (A. & S.), occasionally occurs in sufficient numbers to damage cotton. The following dusts have given good control: Toxaphene 20 percent; sufficient benzene hexachloride to give 3 percent of the gamma isomer plus 5 percent of DDT plus 40 percent of sulfur (commonly known as 3-5-40); chlordane 10 percent; or DDT 10 to 20 percent. A 5-percent DDT dust will control small worms. These dusts should be applied at the rate of 20 pounds per acre. Toxaphene or DDT as sprays applied at the rate of 2 pounds of technical material per acre have also given good control. The results obtained from the above materials have varied in different States; therefore local recommendations are advisable. (Also see Bollworms, p. 21.)

Garden Webworm

The garden webworm, Loxostege similalis (Guen.), may be controlled on cotton by dusts containing 5 percent of DDT plus sufficient benzene hexachloride to give 3 percent of the gamma isomer, 20 percent of toxaphene, or 10 percent of DDT. DDT has given better control in sprays than in dusts and is generally less effective than the other two materials. Calcium arsenate may also be used to control the garden webworm, but heavy poundages are required and control is generally less satisfactory than with the new organic insecticides.

Grasshoppers

Several species of grasshoppers, particularly Melanoplus differentialis (Thos.) and Schistocerca americana (Drury), attack cotton. The adults of S. americana hibernate and deposit their eggs in the fields, but most of the other species overwinter as eggs in untilled soil in fence rows, sod waterways, around stumps, and in similar locations. The latter can best be controlled by early treatment of hatching beds before the grasshoppers migrate into the fields. Sprays or dusts containing aldrin, chlordane, dieldrin, toxaphene, or benzene hexachloride are rapidly

replacing poison baits for grasshopper control in many areas. This is particularly true where grasshoppers must be controlled on lush or dense vegetation.

Benzene hexachloride sprays and dusts usually produce a spectacular kill of the grasshoppers in a few hours, but results have been erratic and residual effectiveness is limited to 1 or 2 days. Aldrin, chlordane, dieldrin, and toxaphene are very effective but are slower in their action. They remain residually effective for 5 to 14 days, however, depending on prevailing environmental conditions.

Dosages suggested to control grasshoppers fall within the following ranges:

	Pounds per acre
Aldrin	0.1 - 0.25
Benzene hexachloride, gamma isomer	0.3 - 0.5
Chlordane	0.5 - 1.5
Dieldrin	0.07 - 0.125
Toxaphene	1.0 - 2.5

The lowest dosage rates suggested are effective against newly hatched to half-grown grasshoppers. The dosage should be increased as the grasshoppers mature or when the materials are applied on partly defoliated plants or on plants that are unpalatable to the insects.

Baits made according to State and Federal recommendations still have a place in grasshopper control where treatment of extensive areas is required, particularly in sparse vegetation.

Pink Bollworm

Methods of controlling the pink bollworm, Pectinophora gossypiella (Saund.), include destruction of cotton stalks immediately after the harvest, heat treatment of cottonseed, burning of gin waste, compression of lint, and the application of dust and spray formulations. In South Texas pink bollworm infestations early in any season are in proportion to the number of these insects that survive the period between crops. The longer this period the fewer insects will survive; therefore, the number of overwintering insects may be reduced by destroying cotton stalks at the earliest possible date. The best procedure is to cut the stalks with a stalk cutter which crushes them to the ground. If this operation is carried out sufficiently early a high mortality of pink bollworms and other cotton insects results from exposure to heat of the sun. The roots should be plowed out promptly and the crop debris plowed under. All seedlings or sprouted cotton plants developing after the plowing should be eliminated before fruiting so as to create a long host-free period between crops. For best results cultural practices should be carried out on an area-wide basis and the cooperation of every cotton

grower is needed. Cultural practices used to control the pink bollworm will also control the boll weevil.

Cotton growers of the Lower Rio Grande Valley of Texas have used the cultural method of control outlined above and, over a 5-year period, lint production averaged 342 pounds per acre. Over a 5-year period prior to the beginning of control by early stalk destruction, lint production there averaged 213 pounds per acre. This increase in yield at current prices amounted to around $17,000,000 for the 1950 crop from about 375,000 acres. The increased production resulted largely from boll weevil control and greater productivity of the soil because of improved farming methods.

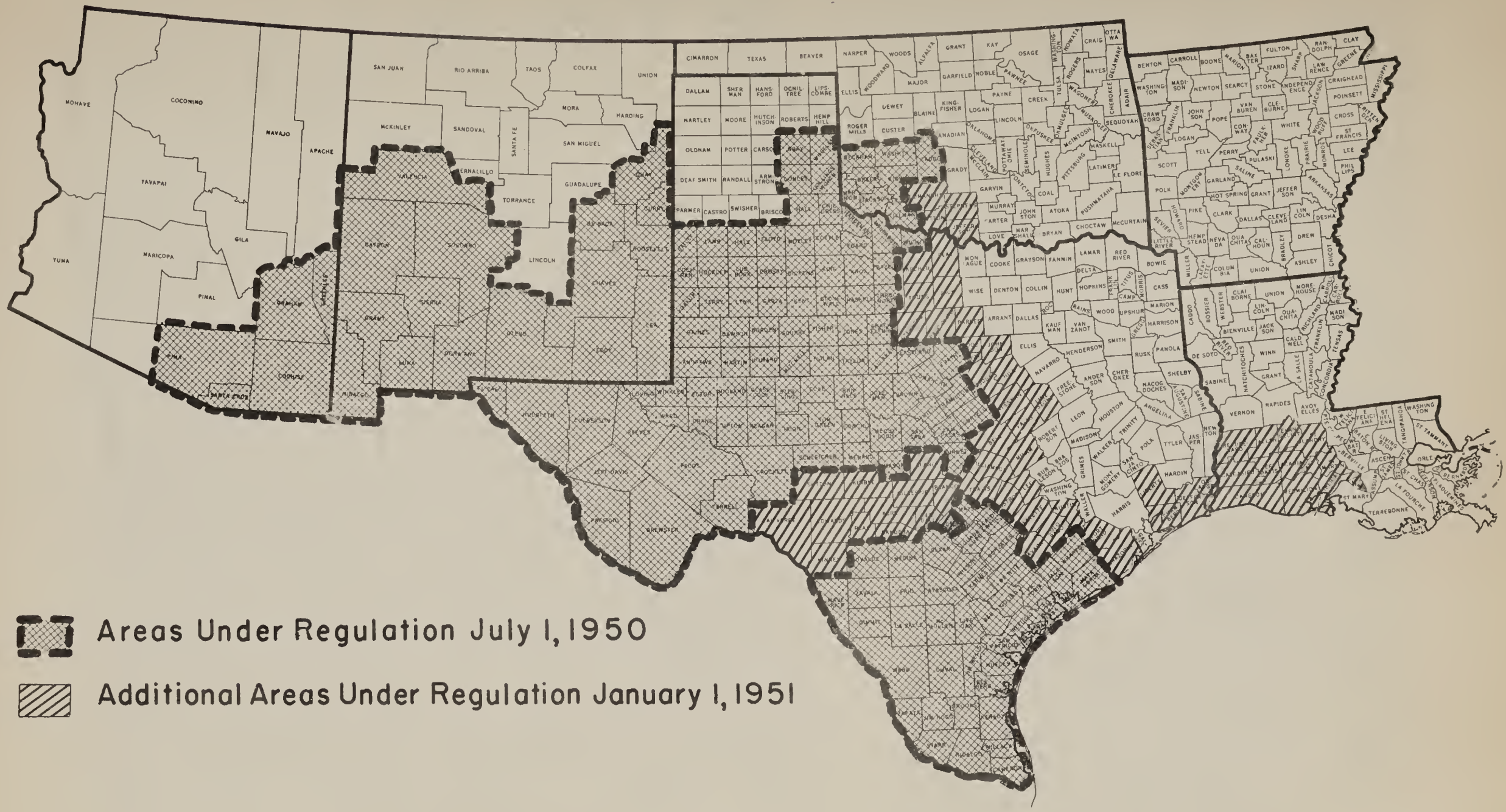
There is a progressive build-up in the pink bollworm population as the season advances; therefore, every effort should be made to expedite fruiting and setting the crop. The following practices are recommended for hastening the maturity of the cotton and thereby reducing the pink bollworm infestation: Heat or chemical treatment of planting seed; early uniform planting of quick-maturing varieties; control of cotton fleahoppers, thrips, aphids, and other insects that delay fruiting; clean cultivation; elimination of late irrigation; and chemical defoliation.

In cold, arid regions, such as the West Texas Area where the harvest must be completed after frost, as many bolls as possible should be removed by snapping, mechanical harvesting, or by heavy pasturing. The cotton stalks should be left standing during the winter months, since the highest mortality of hibernating pink bollworm larvae in such areas is obtained in the bolls on standing stalks. Where the stalks are plowed under early in the winter the fields should be winter irrigated wherever possible.

Larvae of the pink bollworm enter mature cottonseeds to feed and to hibernate. To prevent the overwintering or spread of the insect, cottonseed are given a heat treatment as a continuous process of ginning in much of the pink bollworm quarantined area. In the remainder of the area, cottonseed are heat-treated upon arrival at designated oil mills or other treating plants. In the heavily infested areas a second heat treatment is required before movement into other quarantined or free areas. In all pink bollworm quarantined areas gin waste is destroyed promptly by burning, or heat-treated for use as fertilizer, and all lint is compressed before it is moved into areas that are free of pink bollworm.

DDT continues to be the best insecticide for control of the pink bollworm. It can be applied as a dust or as an emulsion spray. From 1.5 to 2 pounds of technical DDT should be used per acre application. Dust formulations containing 10 percent of DDT should be applied at the rate of 15 pounds per acre. Large-scale demonstration tests, with applications beginning when the cotton is in the 6- to 8-leaf stage, have proved highly effective when followed with later applications as required by infestation conditions of pink bollworms and other insects. These

PINK BOLLWORM REGULATED AREAS
JANUARY 1, 1951



early applications are especially beneficial in shortening the fruiting period. The result is that fewer generations of pink bollworms develop and early stalk destruction is possible. The number of hibernating pink bollworms is thus reduced.

Aphids and spider mites may develop when DDT is used alone for pink bollworm control. Benzene hexachloride and sulfur or parathion may be added to the dust formulations and TEPP may be added to the spray formulations for control of these pests as recommended.

Regardless of the other insects to be controlled, all formulations for control of the pink bollworm should contain sufficient DDT to give the minimum of 1.5 pounds of technical DDT per application per acre irrespective of the other materials or the spacing of applications.

The accompanying map shows the areas under quarantine because of the pink bollworm. Farmers, county agents, ginners, and all others in the cotton industry should cooperate fully with State and Federal quarantine agencies in preventing spread of the pink bollworm, especially with regard to the movement of cottonseed from infested areas.

Spider Mites

Although several species of spider mites are known to attack cotton, two are believed to be of greatest importance as cotton pests--the two-spotted spider mite, Tetranychus bimaculatus Harvey, and a recently described species from Texas, Septanychus texazona McG.

It is known that the use of certain of the organic insecticides for cotton insect control has resulted in serious spider mite infestations.

Sulfur has been the standard recommendation for the control of spider mites for many years, and satisfactory results have usually been obtained from its use. For the control of local incipient infestations, it should be applied at the rate of 20 to 25 pounds per acre.

In some areas organic insecticide dusts for use on cotton are formulated to contain at least 40 percent of properly conditioned dusting sulfur or some other suitable miticide. The use of such formulations has usually prevented damage from spider mites and is recommended.

Dust containing 1 percent of parathion applied at the rate of 10 to 12 pounds per acre is also highly effective against spider mites on cotton.

TEPP at the rate of 0.5 pint of the 40 percent concentrate, or its equivalent, per acre effectively controls heavy populations.

When the organic insecticides are applied as low-gallonage sprays, elemental sulfur cannot be incorporated in the spray formulations. When sprays are being used and the mite population begins to noticeably increase, Aramite, the active ingredient of which is 2-(p-tert.-butyl-phenoxy)-1-methylethyl 2-chloroethyl sulfite, also known as 88R, may be added to the next spray application at the rate of 0.33 pound per acre for rapid and effective control.

Three other new compounds were tested under field conditions during 1950 and appear sufficiently promising to justify recommending for large-scale experimental use during 1951 to bring about rapid and effective control. They are as follows: (1) R-242, also called technical p-chlorophenyl phenyl sulfone, at the rate of 1 to 1.5 pounds per acre; (2) 923, also called technical 2, 4 dichlorophenyl ester benzene sulfonic acid, at the rate of 1.5 to 2 pounds per acre; (3) K-6451, also called technical p-chlorophenyl p-chlorobenzene sulfonate, at the rate of 1.5 to 2 pounds per acre.

Laboratory tests indicate that S. texazona is more susceptible to certain miticides than is T. bimaculatus. Where the latter species occurs, it may be necessary to increase the amounts of the chemicals mentioned.

Overwintering infestations of spider mites survive on low-growing perennials. These can be destroyed by winter cultivation, giving particular attention to normally uncultivated spots around stumps and along margins of fields. Such practices aid in controlling outbreaks.

Tarnished Plant Bug, Rapid Plant Bug, and Related Species

The tarnished plant bug, Lygus oblineatus (Say), the rapid plant bug, Adelphocoris rapidus (Say), and related species such as Creontiades debilis (Van D.) and Neurocolpus nubilus (Say) often cause injury to cotton. The organic insecticides recommended for boll weevil or bollworm control are effective against these plant bugs.

Thrips

Thrips often cause more injury to cotton seedlings than is generally realized, especially in areas where onions and small grains are grown extensively. The destruction of leaf tissue by thrips and the subsequent slow plant growth make the seedlings more susceptible to injury by such fungus diseases as the Ascochyta blight and Rizoctonia damping-off. The combined injury may reduce or even destroy stands of young plants. A heavy thrips infestation will retard plant growth and delay crop maturity. Although reductions in yield may not result, the subsequent delay in crop maturity may lower the quality of seed and lint because of the greater likelihood of damage by insects and deterioration associated with unfavorable weather conditions.

A number of insecticides give satisfactory thrips control when properly applied. Toxaphene at the rate of 0.5 to 1 pound per acre, in either dust or spray form, gives effective control. A spray mixture consisting of 0.66 pound of toxaphene and 0.33 pound of DDT per acre or a dust mixture containing 5 percent of DDT and sufficient benzene hexachloride to give 1 percent of the gamma isomer applied at the rate of 12 to 15 pounds per acre is also effective.

Aldrin applied to young seedlings as a spray or dust at the rate of 0.08 to 0.125 pound per acre gives good thrips control. Dieldrin applied at the rate of 0.05 to 0.1 pound per acre is very effective.

Other insecticides which give satisfactory control either as a spray or a dust at indicated rates per acre are chlordane 0.5 to 1 pound, benzene hexachloride 0.1 to 0.15 pound, heptachlor 0.25 to 0.5 pound, and DDT 0.25 to 0.5 pound. DDT has not given satisfactory control at temperatures above 90° F.

Although some of the phosphate compounds are effective against thrips, they are extremely poisonous and must be handled with great care.

Tobacco Budworm

See Bollworms, p. 21.

White-Fringed Beetles

The white-fringed beetles, Graphognathus leucoloma (Boh.), G. peregrinus (Buch.), and G. minor (Buch.), which are pests of cotton and many other farm crops, are known to be present in limited areas of Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee.

Larvae of the white-fringed beetles damage cotton by feeding on the roots of young plants. These insects can be controlled by the use of good cultural practices and insecticides. Good cultural practices recommended include the following:

1. Plant oats or other small grains in heavily infested areas.
2. Restrict planting of summer legumes, such as peanuts, soybeans, velvet beans, or other favorable host plants of the adult beetles to not more than one-fourth of the total crop land. Do not plant these crops on the same land more often than once in 3 or 4 years.
3. Do not intercrop corn with peanuts, soybeans, crotalaria, or velvet beans. Prevent the growth of broadleaved weeds, such as cocklebur and sicklepod.
4. Improve poorer soils by turning under winter cover crops.

DDT is effective as a soil insecticide for control of white-fringed beetle larvae. Apply 50-percent DDT at the rate of 20 pounds per acre or 25-percent DDT at the rate of 40 pounds per acre evenly to the soil surface as a dust, spray, or mixed with sand, and then thoroughly mix it into the upper 3 to 4 inches of soil. This treatment will give control of larvae for at least 5 years. DDT may be used in the drill before planting. Use 50-percent DDT at the rate of 5 to 10 pounds per acre,

or 25-percent DDT at the rate of 10 to 20 pounds per acre, mixed with sand. This may be applied by hand or by a fertilizer distributor, at or slightly below the depth of seed planting.

Either toxaphene or a benzene hexachloride-DDT mixture applied on cotton foliage gives a residue in the soil, which aids in the control of white-fringed beetles. These insecticides should be used for the control of those cotton insects for which they are recommended in white-fringed beetle infested areas.

Wireworms

Several species of wireworms are associated with cotton. Perhaps the most noticeable damage is caused by the sand wireworm, Horistonotus uhlerii Horn., in South Carolina, Louisiana, and Arkansas. Adults of the tobacco wireworm (spotted click beetle), Conoderus vespertinus (F.), are frequently found on the cotton plant, but the amount of damage to cotton caused by the larvae of this species is not known.

Approved crop rotation practices, increased soil fertility, and added humus help to reduce damage to cotton caused by the sand wireworm. Chlordane, DDT, lindane, and benzene hexachloride have shown promise in the control of this and other species of wireworms on other crops. Additional research on the control of wireworms attacking cotton is needed.

Yellow-Striped Armyworm

See Bollworms, p. 21.

Miscellaneous Insects

Cabbage looper, Trichoplusia ni (Hbn.): The cabbage looper and several other closely related species occasionally cause damage to cotton in localized areas. Dusts containing 5 percent of DDT or 10 percent of toxaphene, applied at the rate of 10 pounds per acre, or sprays containing toxaphene or DDT applied at the rate of 1 pound and 0.5 pound per acre, respectively, are effective.

Corn silk beetle, Luperodes brunneus (Crotch): This insect has been reported as a pest of cotton in localized areas in several States but little is known about it.

Cotton root aphids: The species of root aphids known to attack cotton are the corn root aphid, Anuraphis maidi-radicis (Forbes); Triphidaphis phaseoli (Pass.); and Rhopalosiphum subterraneum Mason. So far as is known, injury by root aphids to cotton is confined to the Eastern Seaboard. Several species of ants are known to be associated with root aphids, the principal one being the cornfield ant, Lasius niger

alienus americanus Emery. Chemical control of root aphids has been directed at control of the cornfield ant. Some of the newer materials are known to be effective as soil insecticides, and it is suggested that they be tested against root aphids attacking cotton. Root aphids injure cotton chiefly in the seedling stage. Since cotton in this stage often shows signs of injury without any evidence of insects being present, it is suggested that careful examinations be made of the underground portions to determine the possibility of root aphid attack. Ant mounds at the base of seedling plants indicate the presence of root aphids.

Cotton square borer, Strymon melinus (Hbn.): The cotton square borer occurs throughout the Cotton Belt, but rarely causes economic damage. The injury caused by the insect to squares is ofter attributed to the bollworm.

Cotton stainer, Dysdercus suturellus (H.-S.): The cotton stainer occurs within the continental limits of the United States in Florida only. However, probably due to mistaken identity, the literature also records it from Alabama, Georgia, and South Carolina. No work has been formally reported in recent years on control, but observations indicate that dusts containing 10 percent of toxaphene or sufficient benzene hexachloride to give 1 percent of the gamma isomer will control insects of this genus. There are indications that DDT may also be effective in some areas.

Cowpea aphid, Aphis medicaginis Koch: The cowpea aphid occurs commonly on very young cotton, especially on the cotyledonous leaves. Cotton is not believed to be a true host of this species and the insect will not complete a life cycle on the cotton seedling.

Darkling beetles: These insects damage young cotton in some areas. They can be controlled with 5-percent chlordane dust applied at the rate of 20 pounds per acre, or with toxaphene, DDT, or a toxaphene-DDT 2 to 1 mixture applied as sprays at the rate of 1 to 2 pounds of technical material per acre.

Flea beetles: These insects are serious pests of cotton in some areas. The same insecticides recommended for thrips control will control flea beetles.

Grape colaspis, Colaspis flavida (Say): Calcium arsenate and DDT have given satisfactory control of this insect on cotton.

Salt-marsh caterpillar, Estigmene acrea (Drury): The salt-marsh caterpillar can be controlled with toxaphene applied as either a dust or a spray at the rate of 3 pounds of technical material per acre, preferably when worms are small.

Insects That Attack Cottonseed in Storage

Cottonseed rarely becomes infested with insects while in storage, if proper precautions are followed. Cottonseed or seed cotton should be stored only in a bin or room that has been thoroughly cleaned of all old cottonseed, grain, hay, or other similar products in which insects that attack stored products are likely to develop. Among the insects that cause damage to stored cottonseed or to cottonseed meal are the cigarette beetle, Lasioderma serricorne (F.), the Mediterranean flour moth, Ephestia kühniella Zell., and the Indian-meal moth, Plodia interpunctella (Hbn.). Cottonseed that is to be used for planting only may be dusted with toxaphene before being placed in storage. Seed so treated should not be crushed or used for feed.

Parasites and Predators of Cotton Insects

Parasites and predators aid greatly in the control of insect pests of cotton. However, their help cannot always be relied upon and it is usually necessary to use cultural control practices and to spray or dust the cotton with insecticides. Extensive investigations, which have included the importation and colonization in cotton fields of several insect parasites of the pink bollworm, have shown that so far the use of these natural enemies of cotton insects has limitations.

Cotton Insect Surveys

The importance of surveys to an over-all cotton insect control program has been clearly demonstrated during the last few years. Cotton insect surveys conducted on a cooperative basis by State and Federal agencies in most of the major cotton-growing States have developed into a broad, currently advisory service for the guidance of the farmer, others associated with cotton production, and the industry that serves the farmers by supplying insecticidal chemicals. As a result of survey work, farmers are forewarned of the insect situation and losses are materially reduced below what they would be without the information thus gained. The survey also helps to direct insecticides to areas where supplies are critically needed.

More people are being employed each year by business firms, individual farm operators, and others interested in cotton production to determine cotton insect populations. It is important that individuals employed by private interests to make surveys understand the control programs as well as how to make infestation counts. Therefore, State and Federal entomologists should assist in locating personnel that have at least some basic training in entomology to do survey work for private interests. If this is not done, many growers are sure to be misinformed about recommended control practices.

Information obtained through surveys on insect populations has done much to create interest in cotton insect control programs. When survey data are collected, interpreted, and disseminated at weekly intervals, it is helpful to growers, the insecticide industry, entomologists, and all others interested in an effective control program. The extent and intensity of the coverage largely determine the value of surveys. It is the type of service that can be supplied only through leadership and cooperative undertaking. Therefore, it is recommended that cotton insect surveys be continued, that they be placed on a permanent basis, and that they be expanded to include all cotton-producing States.

Wherever possible, it is well to enlist and train voluntary cooperators to make field observations and records and to submit reports during the active season. Wider dissemination of the information that is compiled is highly desirable.

Extension Educational Programs for 1951

There is a serious need for a strong educational program that will present the facts concerning cotton insect control. This program should be conducted in such a way that everyone interested in cotton production will be reached. Growers especially need these facts to help them in making plans for 1951.

In order that cotton growers may follow without confusion the recommendations made by the State and Federal entomologists, such recommendations must be basically the same in areas where the insect problems are similar. Points upon which agreement must be reached are: (1) Insecticides that are effective, economical, and safe to use with proper precautions; (2) time to start treatment; (3) rate of application; (4) interval between applications; and (5) how to apply the insecticides. If these points are not agreed upon, the confusion that develops will seriously interfere with effective insect control.

To facilitate the production of a 16,000,000-bale crop of cotton in 1951, the Extension Service will immediately strengthen and intensify its educational work on the seven-step cotton-production program. To help accomplish the goal each State should have the following committees: (1) A State-wide cotton production committee made up of representatives from all agencies and organized groups within the State to help develop, promote, and provide leadership to the program; (2) a technical committee made up of representatives from all State and Federal agricultural agencies to prepare recommendations on cotton production and insect control; (3) an extension committee selected by the State Director, which will be responsible for the educational program. Each county or parish should be organized on a basis somewhat comparable to that of the State.

Experience has shown that committees such as those outlined above play an important part in the planning and carrying out of an integrated program in which all agencies and segments of industry can cooperate. As a result of the cooperative effort, growers will be kept informed of the need for insect control and industry will know better the needs for insecticides.

The following steps listed on a seasonal basis outline the extension program that will be carried out in varying degrees in the Cotton States:

Winter

A. State or area meetings with insecticide suppliers and applicators.
B. District meetings with county agents and farm leaders.
C. General county (parish) meetings, stressing early purchase and farm storage of insecticides and equipment.
D. Preparing and issuing radio and newspaper releases, circular letters, and posters on early purchase and farm storage of insecticides and equipment.
E. Securing of cooperation with the farm loan agencies, oil mills, ginners, fertilizer associations, and other groups concerned with the production of cotton.

Spring

A. Surveys by State and Federal entomologists to determine boll weevil survival.
B. Continuation of meetings on cotton insect control. Giving of information on the survival of boll weevils and the control recommendations.
C. Newspaper and radio releases on boll weevil survival.
D. Demonstrations on procedure for making boll weevil counts per acre in order to determine when and where early boll weevil control is needed.
E. Counts of boll weevils per acre on seedling cotton.
F. Recommendations on early season control of boll weevils, thrips, and other cotton insects.
G. At least one 4-H Club meeting devoted to cotton insects and their control.

Summer

A. Square infestation counts by State and Federal entomologists, county agents, and community workers.

B. Field demonstrations on insect identification, infestation counts, and proper application of insecticides.
C. Timely radio programs, newspaper articles, and circular letters on insect conditions and control.
D. Field tours to study demonstrations and experiments on cotton insect control.
E. Daily radio reports on weather conditions.

Fall

A. Stressing of importance of defoliation in preventing insect damage to young bolls.
B. Promoting an early stalk destruction program to reduce insect populations.

Full use should be made of the following educational tools to stimulate the adoption of recommended practices:

1. Publications--yearly recommendations.
   a. Plan of organizational set-up showing responsibility of each agency.
   b. Yearly recommendations for insect and disease control.
2. Mimeographed informational material.
3. Posters, charts, exhibits at fairs, models.
4. Magazine articles.
5. Cotton letter or other circular letters.
6. Newspaper publicity, special editions.
7. Radio spot announcements and recordings. Sponsored program at set time and day each week so as to build up a listening audience for the program.
8. Public meetings.
9. Individual contacts.
10. Slides and motion pictures.
11. Television where available.
12. Equipment displays at method demonstrations.
13. Result demonstrations.
14. Visits to Experiment Stations.

Needed Research

Additional information is needed on the following subjects:

1. Spray formulations for use in the control of cotton insects.
   a. Solvents and emulsifiers.
   b. Re-evaluation of toxicants and mixtures of toxicants.
2. Designs of machinery and equipment for applying sprays and dusts, including aircraft particularly adapted to various agricultural needs.

3. The value of community action in controlling cotton insects.
4. The physiological and phytotoxic reaction of insecticides to plants.
5. The interrelationship between vegetation and fruiting of the cotton plant, with special reference to the timing of insecticide applications.

Basic information is needed on the following subjects:

1. The comparative toxicity of different insecticides and combinations.
2. Defoliation in relation to the control of cotton insects.
3. The effect of early-season infestations on the subsequent development and yield of cotton.
4. The physiological mode of action of insecticides on insects.
5. The effect of sublethal dosages of insecticides upon insect reproduction and development.
6. The effect of temperature, humidity, sunlight, rainfall, and air currents upon the effectiveness of insecticides.
7. Improved techniques for testing insecticides.
8. The effects of insecticides upon natural enemies of cotton insects.
9. The effects of insecticides applied to cotton upon soils and subsequent crops.
10. The effect of insecticides upon livestock, poultry, wild life, and man.
11. The possibility of contamination of food products by organic insecticides applied for the control of cotton insects.
12. The possibility of the development of insect resistance to insecticides.
13. Factors influencing the deterioration of insecticides in storage.
14. The effects of insecticides on honey bees and other pollinating insects.
15. The relation of factors, such as coverage, particle size, distribution, adherence, and residual toxicity of insecticides, to cotton insect control.
16. The effect of ecological factors, cropping systems, natural enemies, cultural practices, and plant nutrition upon cotton insect populations.
17. Combining insect control with other operations in mechanized production of cotton.
18. The seasonal development, life histories and habits of the major cotton pests and others that are potentially injurious.
19. Possible insect vectors of cotton diseases.

Conferees at the Memphis, Tenn. Conference

Entomologists and associated technical workers interested in cotton insects from the Agricultural Experiment Stations, Extension Services, and other State agencies in 12 cotton-growing States, Puerto Rico, the United States Department of Agriculture, and the National Cotton Council of America participated in a Cotton Insect Research and Control Conference at the Gayoso Hotel, Memphis, Tenn., on December 4, 5, and 6, 1950. The statements in this report were agreed upon by the 76 conferees listed below:

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Charles G. Lincoln, Ent., Agr. Ext. Serv., Fayetteville

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